PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Turbo-Generators

We, AKTIENGESELLSCHAFT BROWN, BOVERI & CIE., of Baden, Switzerland, a Swiss Company, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement: —

The invention relates to turbo-generators wherein the rotor winding as well as the stator iron are cooled by means of a gas and the stator winding is cooled by means of a liquid.

This type of machine which nowadays has to be built for very high powers, has a considerable length which involves certain difficulties regarding direct cooling of the conductors. The tendency is therefore to improve the removal of the heat losses in such a manner that a rational and effective cooling is easily achieved, even for machines having long bar conductors.

The object of the present invention is to achieve an improvement with respect to the arrangements used hitherto, and the desired results is obtained in that the gaseous coolant is passed to the middle of the machine between the stator core and the casing, then through radial slots in the stator iron from the outside towards the inside of the stator iron, then the coolant is deflected in an axial direction through longitudinal channels in the stator iron towards each outer end of the stator iron from whence it passes through pressure plates at the stator ends into end spaces, the gaseous coolant being extracted from said spaces by means of fans fixed to the rotor shaft and passed back to the middle of the machine by way of coolers.

A turbo-generator is shown in the accompanying drawing as a constructional example of the present invention.

The turbo-generator in this example comprises a rotor 1 and a stator 2 which are located in a gastight casing 3 filled with a gaseous coolant, for instance hydrogen. The stator 2 includes a laminated stator iron core 4 with pressure plates 5 and stator winding 6. Longitudinal cooling channels 7 are provided in the stator iron. The conductors of the stator winding 6 are cooled directly with a liquid, for instance water or oil, by known means and for this purpose the conductors' bars are made partly hollow or cooling ducts are provided in the winding slots. The rotor 1 is also provided with axial cooling channels for cooling directly the conductors in a manner known *per se*, and the middle of the machine these channels are in communication with an air gap 9 of the machine by way of ports 8. A fan 11 is mounted on each end of rotor shaft 10, and 12 indicates coolers which are located in the longitudinal space between the stator core and the casing 3.

The method of operation of the cooling arrangement is as follows: —

Due to the suction of the fans, the coolant gas between the casing and stator core flows to the middle of the machine then through radially directed slots 13 provided in the laminated stator core 4, the gas flowing from the outside towards the inside, and after being deflected by 90° then passes along the longitudinal channels 7 in opposite directions through the stator iron, finally discharging through passages in pressure plates 5 into end spaces 14. The gas which has become heated in the stator iron is conveyed from the end spaces 14 by means of the fans 11 to the coolers 12 and after giving up its heat flows from the coolers at each end back again to the middle of the machine where it re-enters the stator iron core 4.

For the purpose of cooling the rotor 1, part of the gas for example after leaving the coolers 12 flows through by-pass ducts 15 to both ends of the rotor where it enters axially extending cooling channels and passes to the middle of the rotor where it flows by way of the ports 8 into the air gap 9

[*Price 4s. 6d.*]

between the stator and rotor and finally reaches the suction side of the fans. Dead space at the middle of the rotor between the ports 8 is cooled by gas from some of the slots 13; for this purpose openings 16 are provided in the stator iron. In the embodiment of the invention which has been illustrated, the same fans 11 are used for circulating the gaseous coolant through the stator iron and the rotor. It is, however, also possible to provide additional fans on the rotor shaft which serve only for circulating the required gaseous coolant through the rotor.

For cooling the stator winding 6, a liquid is conducted in a closed circuit through longitudinal cooling channels in the stator bars, the liquid being introduced at one end of the stator and discharged at the other end of the stator. Circulation of the liquid coolant is effected in a known manner, by means of a pump and a cooler located outside the machine. The cooling channels for extracting heat from the stator conductors are so dimensioned that the non-symmetrical temperature rise created in the stator winding due to the unilateral flow of the liquid coolant from one end of the stator to the other, is limited to a few degrees centigrade. The total thermal symmetry of the machine remains thus practically undisturbed.

The number and cross-sections of the cooling channels in the stator iron core can be so dimensioned that the difference in temperature in the iron core will be very low, that is to say for example less than 15° C. from the middle to the ends, while a higher gas temperature rise can be allowed in the pressure plates. By this means one obtains, despite a lower temperature in the magnetically active parts, a high gas temperature at the outlet from the magnetically inactive pressure plate and from the rotor. A small amount of circulated gas is thus sufficient, and this results in small coolers, small fans, and low ventilation losses.

There is also the additional advantage that the axial flow in the stator iron permits of a simple structure of the iron core, since only a few radial slots have to be provided near the middle of the stator iron. The flow of the gaseous coolant in the iron core is required to be deflected only once by 90° so that the flow resistance remains quite low.

WHAT WE CLAIM IS:—

1. A turbo-generator wherein the rotor winding as well as the stator iron are cooled by means of a gas and the stator winding by means of a liquid, characterised in that the gaseous coolant is passed to the middle of the machine between the stator core and the casing, then through radial slots in the stator iron from the outside towards the inside of the stator iron, then the coolant is deflected in an axial direction through longitudinal channels in the stator iron towards each outer end of the stator iron from whence it passes through pressure plates at the stator ends into end spaces, the gaseous coolant being extracted from said spaces by means of fans fixed to the rotor shaft and passed back to the middle of the machine by way of coolers.

2. A turbo-generator as claimed in Claim 1, characterised in that part of the gaseous coolant leaving the coolers is passed to both ends of the rotor and flows through longitudinal channels in said rotor to the middle of the rotor where by way of ports in the rotor it discharges into an air gap between the stator core and the rotor and flows from there back to the end spaces.

3. A turbo-generator as claimed in Claim 2, characterised in that the circulation of the gaseous coolant for the stator iron and the rotor winding is effected by the same fans.

4. A turbo-generator as claimed in Claim 2, characterised in that additional fans are provided for circulating the gaseous coolant for the rotor winding.

5. A turbo-generator as claimed in Claim 1, characterised in that the cooling of the stator winding is effected by means of a liquid in a closed circuit, the liquid coolant being passed from one end of the winding to the other through channels in the conductors.

6. A turbo-generator as claimed in Claim 2, characterised by the feature that part of the gaseous coolant flows from the radial slots into the air gap from whence it flows back to the end spaces.

7. A turbo-generator substantially as herein described with reference to the accompanying drawing.

MARKS & CLERK.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*